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Feasibility Study of Neural Networks Interpolation Applied to Synthetic Aperture Radar Deformations

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Context

- Need to survey a very large number of civil structures that are aging^[2] and validate new ones performances
- Recent technological advances for economical and practical on site monitoring
- Availability and progress in data acquired by satellite Synthetic Aperture Radar (SAR)
- Challenge of Structural Health Monitoring (SHM) based on modal parameter analysis has to deal with environmental variations^[3]

Objectives

Study the feasibility of using surface deformation measurements from Differential Interferometric SAR (DInSAR) technology to subsidence characterization and quasi-periodic monitoring of civil infrastructures.

Particularly in case of lack of information inherent to the DInSAR satellite measurements.

Results

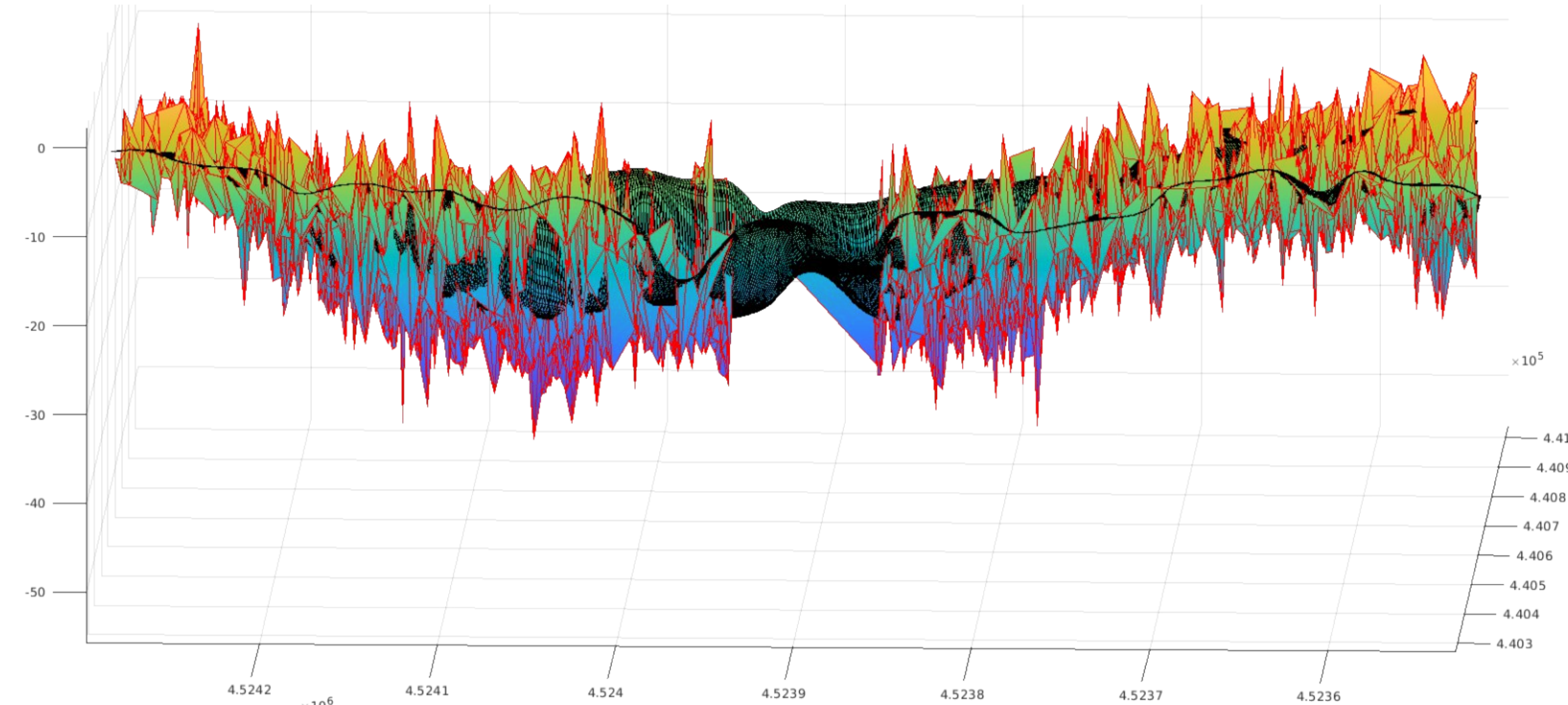


Fig. 3 : Interpolated subsidence data, profile view.

DInSAR Peculiarities^[1]

- Robustness of estimated ground deformation by combining the Line-of-sight (LOS) deformation measurements of complementary ascending and descending orbits data, for which the **measurements points and date of acquisition could be different**;
- Sparse, or absence of, measurements points** on some areas induced by strong decorrelation phenomena;
- Limited range of the actual structure deformation** that could reach the accuracy of the DInSAR technology.

Needs

- ⇒ Interpolate data on a regular grid to overcome missing points and have the same points for both orbits (spatial)
- ⇒ Fusion of the different dates for two acquisition trajectories (temporal)

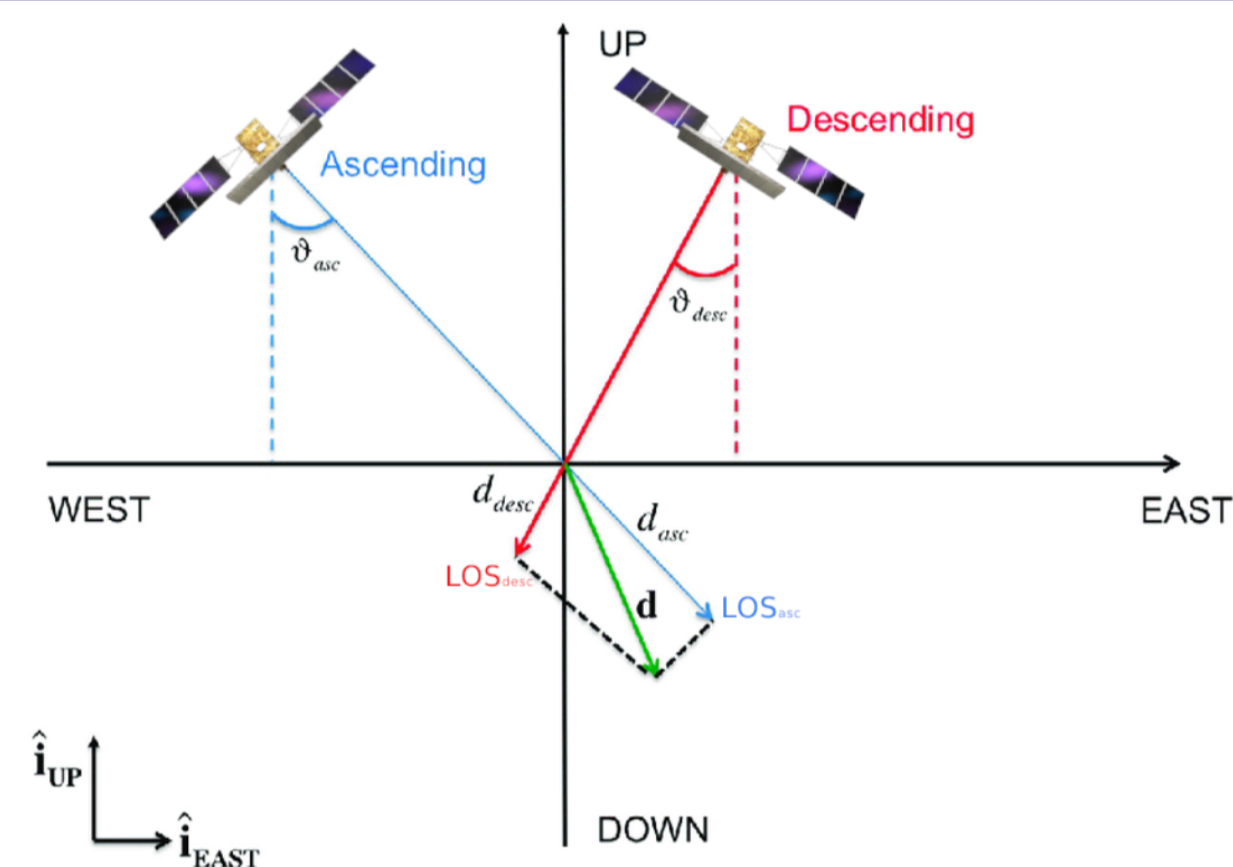


Fig. 1 : Imaging geometries of SAR observations over ascending and descending orbits

Dataset and Methodology

Naples dataset (Italy)

- Railway with missing observations on ground due to a crossing bridge

Data processing

- Extraction of points from AOI
- Projection, rotation and normalization of the points for inputs to the interpolation

Inputs

- Dataset of subsidence
- Dataset of shapes for Area-of-interest (AOI)

- Grid generation
- Projection, rotation and normalization of the grid for inputs to the interpolation

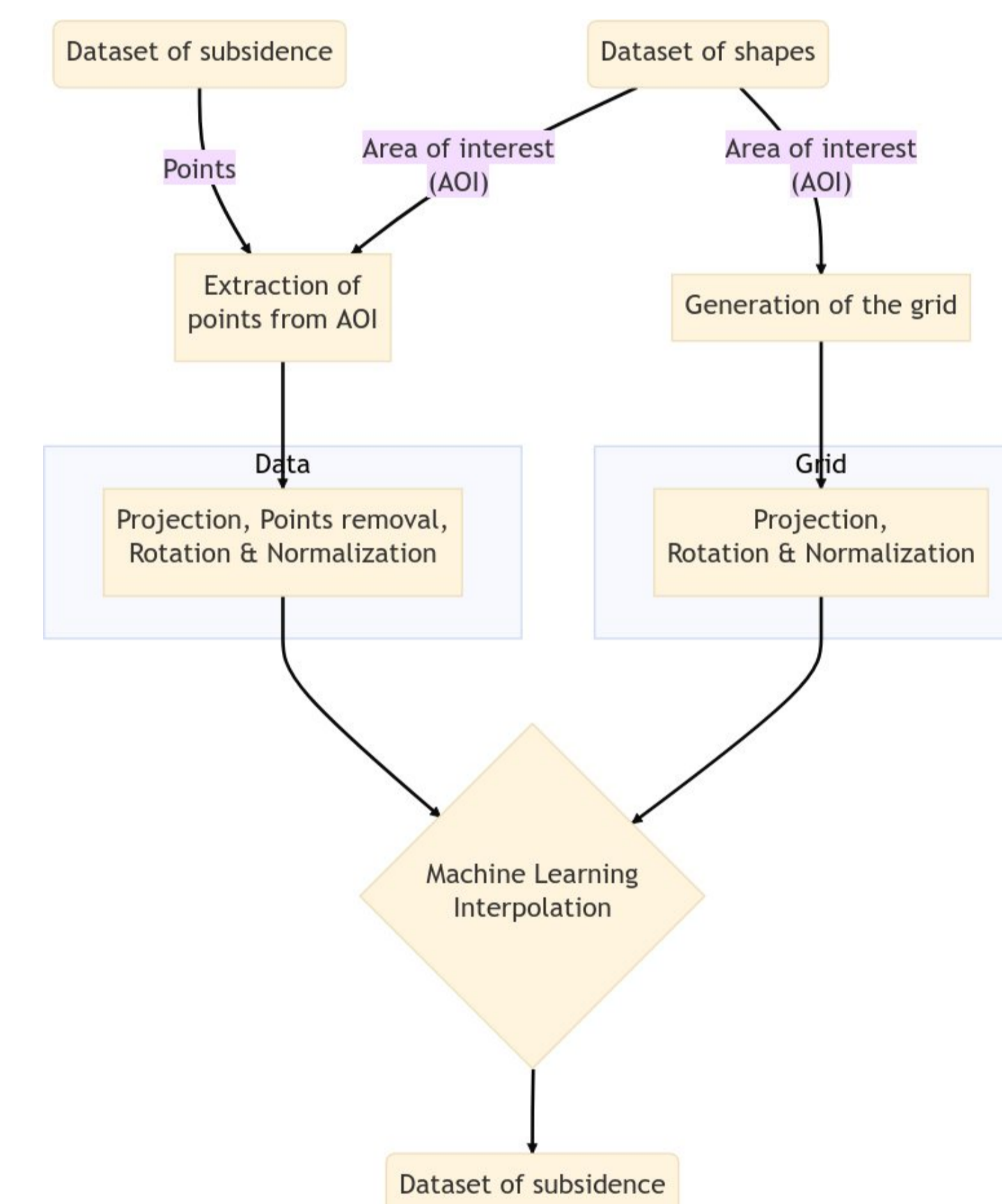


Fig. 2 : Workflow of the developed algorithm



Fig. 4 : Estimated velocity map on the regular grid in mm/year (interpolated)

Interpolation

- Kriging is a well known spatial interpolation method for providing the best linear unbiased predictor. But relies on the fit of a variance model, often optimistic.
- ⇒ Interpolation based on DeepKriging^[4]

- A special training grid for the network is created
- For each acquisition point, the distance to each point of the grid is calculated.
- The distances are recalculated in a process comparable to an inversion. This modified distance will be the input to the neural network. Thus, for an acquisition point, the closer a point in the training grid is, the greater the input value of the neural network is.
- The result of the network is the estimated subsidence of each points of the grid.

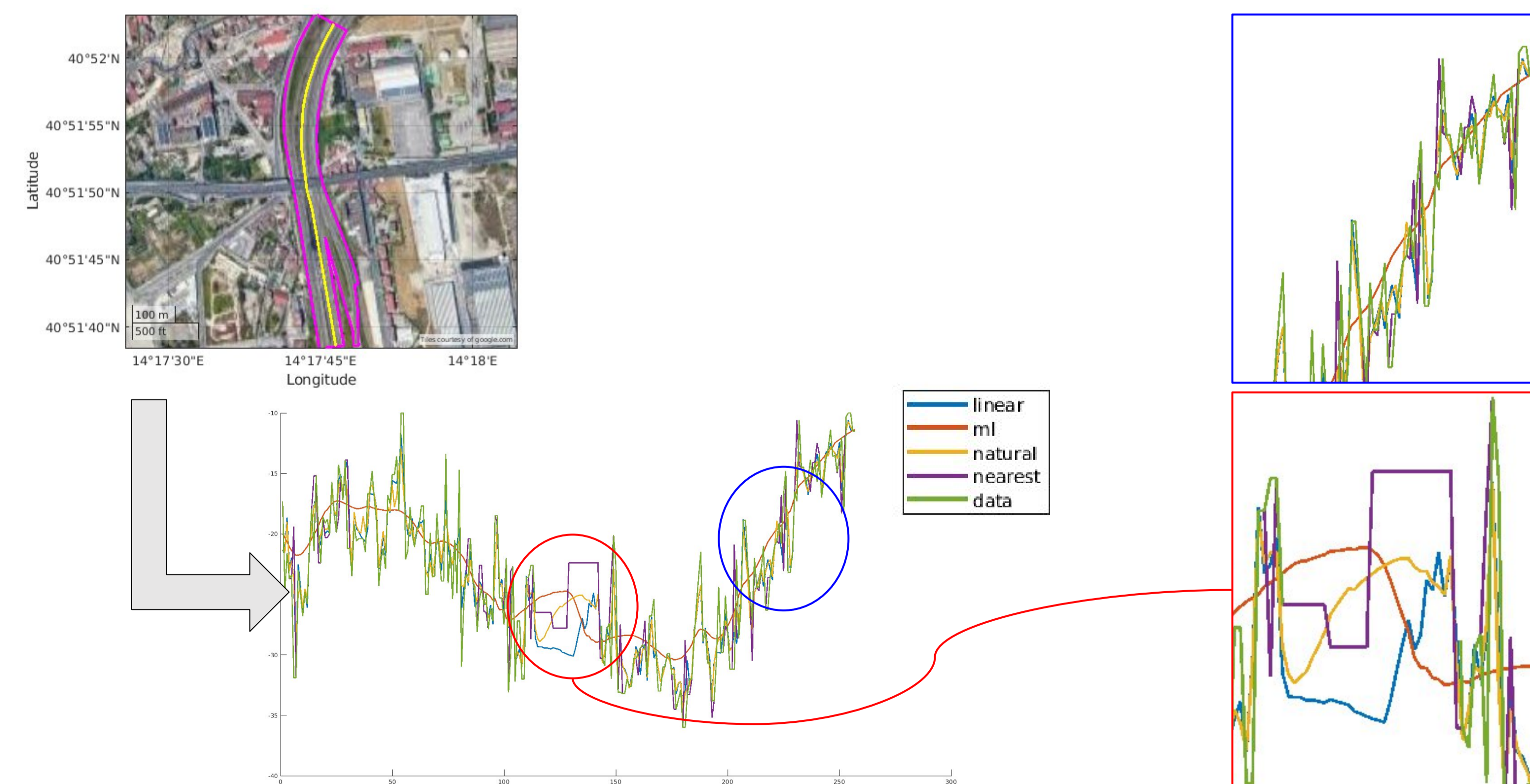


Fig. 5 : Comparison of the DeepKriging interpolation (orange) with a linear (blue), nearest (purple) and natural (yellow) interpolations. Original data in green.

Conclusion

- Development of a processing toolchain applied to DInSAR data for DeepKriging
- To our knowledge, first Neural Network Interpolation on DInSAR data
- Results are promising but need to be validated with ground truth experiments

Perspectives

- Adjustments in the network could be made to further improve the interpolation
- Testing the approach on a monitored bridge in Nantes (France)
- Perform the interpolation on both orbits to combine them

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